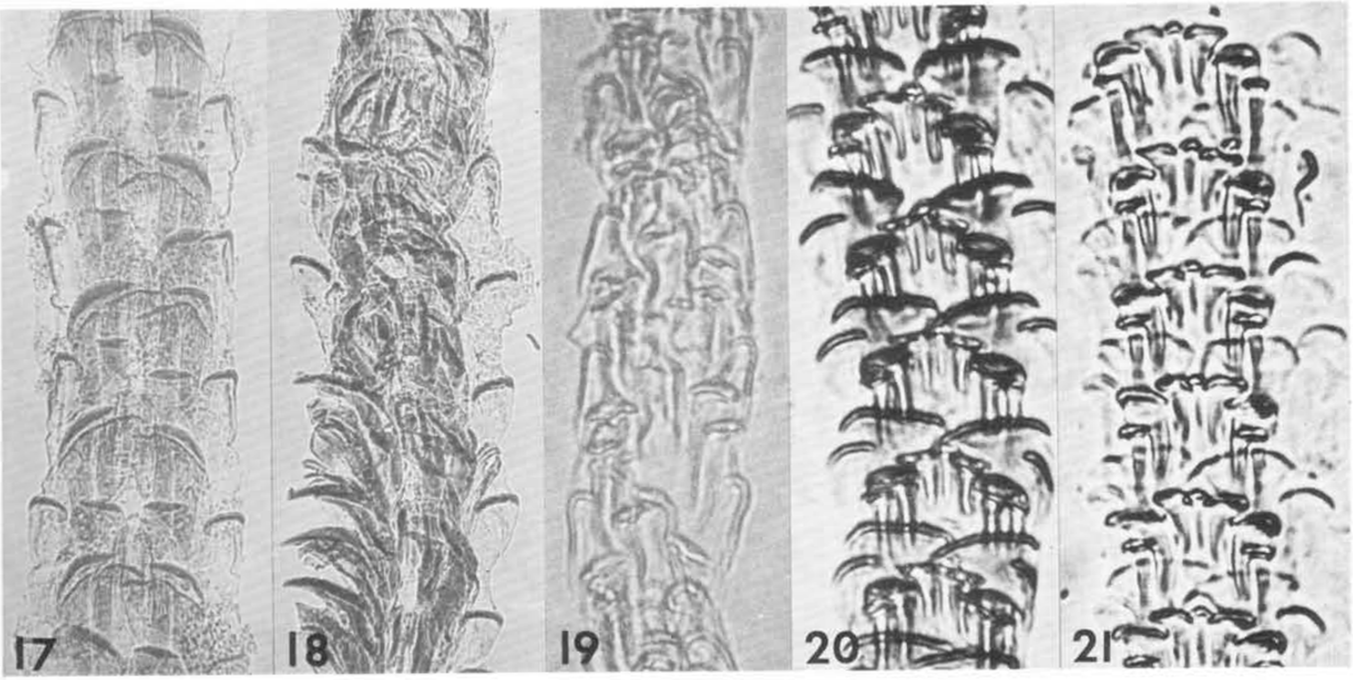


FIGURES 17–21. Neopilinid radular ribbons, magnifications adjusted to show a similar number of teeth rows. FIGURE 17, *Vema (Vema) ewingi,* intact ribbon with teeth aligned (LACM 65–11, 6200 m, 110 mi. W of Callao, Peru, R/V ANTON BRUUN, 24 November 1965). FIGURE 18, *Vema (Vema) ewingi,* another portion of same ribbon with lateral teeth turned to the side. FIGURE 19, *Neopilina veleronis,* intact ribbon of paratype, teeth not aligned (AHF 603, 2730–2769 m, 30 mi. W of Natividad Island, Baja California, Mexico). FIGURE 20, *Vema (Laevipilina) hyalina* new species, intact ribbon with teeth aligned, focused on shafts of lateral teeth (LACM 19148). FIGURE 21, *Vema (Laevipilina) hyalina,* same ribbon, focused on fringe of first marginal teeth.

instead of the highly reduced condition in these two species. Although the first lateral of *N. veleronis* is somewhat larger than it is in the other two species, that of *V. hyalina* is still the larger. The fringed first marginal of *V. hyalina* is much broader than in *N. veleronis*. Only in *V. hyalina* is the fringed tooth so broad that it overlaps the opposite member in the central part of the ribbon. The second and third laterals of *V. hyalina* are not significantly different from those of the other three species, whereas the second marginal is similar to those of *N. galatheae* and *V. ewingi,* but not the exceptionally long second marginal of *N. veleronis*.

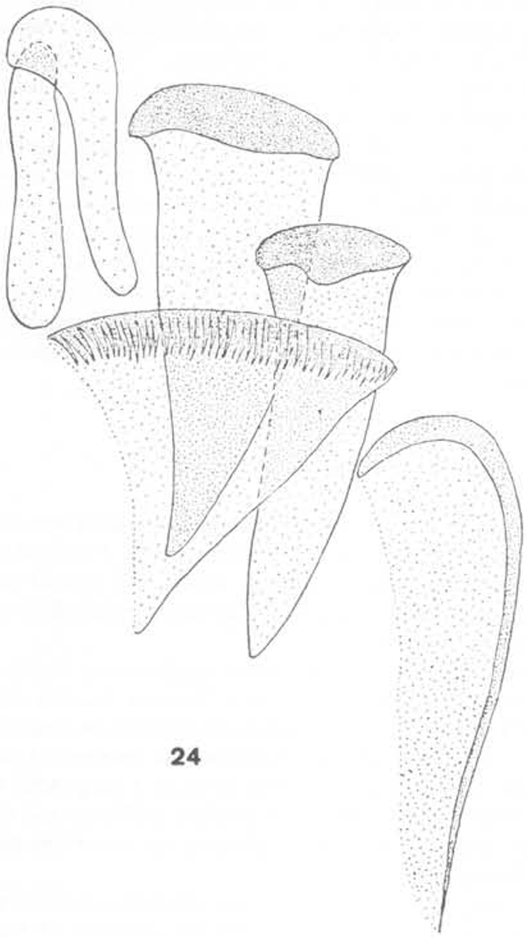
To summarize the radular differences noted among the four species: *Vema hyalina* exhibits major differences in two of the five teeth compared to the two rather similar species *N. galatheae* and *V. ewingi,* whereas the condition of these two teeth in *N. veleronis* is intermediate between these two species and *V. hyalina*. The radula of *N. veleronis* is unique in the extreme elongation of the second marginal.

The radular differences noted in the four species do not correlate with the existing generic division based on number of gill pairs, five in *Neopilina* and six in *Vema*. The only correlation is in size. Both large-sized species have similar teeth and the two small-sized species have similar teeth. Radular differences among the species examined are quantitative rather than qualitative, supporting placement of the four species in the same family. A study of the radulae of the other three living species of neopilinids should reveal further specific differences.

The radula of neopilinid monoplacophorans is very similar to that of chitons and patellacean limpets having the docoglossate radula. In the three groups the radula has in common: a reduced or absent rachidian; strong, hook-shaped lateral teeth; and few, weakly developed marginal teeth. Lemche and Wingstrand (1959) found major similarities in the radular supportive mechanism in *Neopilina* and chitons. Golikov and Starobogatov (1975) discusssed the similarities in form and function of the docoglossate radula with that of chitons and neopilinids.

The docoglossate radula has long been known to function in a way that differs from that of other gastropods. Fretter and Graham (1962:200) gave a detailed comparison of radular function in the two kinds of radulas. In the docoglossate radula there is no longitudinal bending; the entire ribbon works as a rasp with numerous rows functioning at once. In the rhipidoglossate and other non-docoglossate radulae, rows of teeth bend longitudinally

FIGURES 22–25. Radular dentition of neopilinids, drawn from slides photographed in figures 17–21. FIGURE 22, *Vema (Laevipilina) hyalina* new species. FIGURE 23, *V. (Vema) ewingi*. FIGURE 24, *Neopilina veleronis*. FIGURE 25, *N. galatheae,* after Lemche and Wingstrand, 1959. Teeth from left to right are the rachidian; first, second, and third laterals; fringed first marginal; and the outermost, second marginal. Drawings by Mary Butler.



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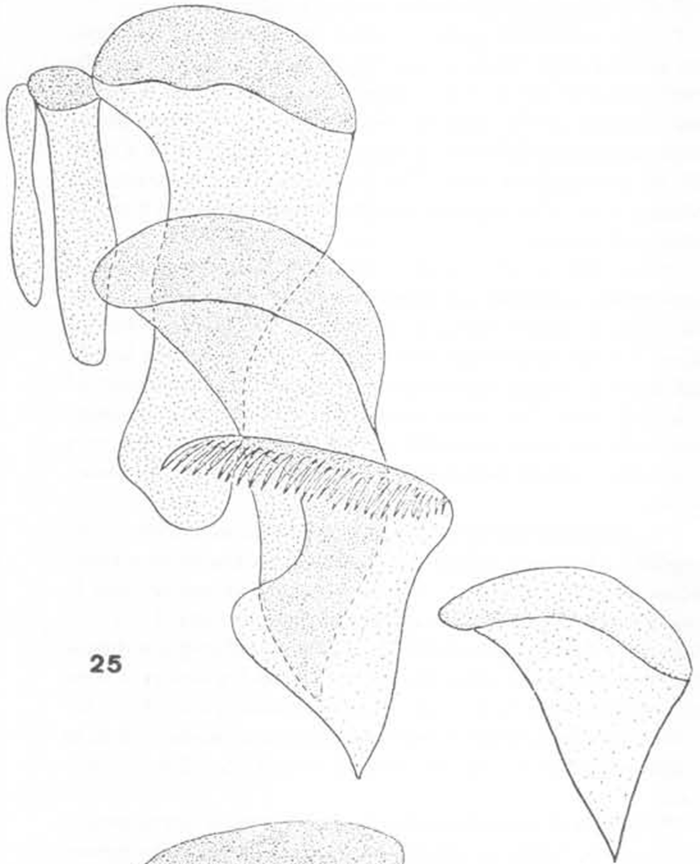

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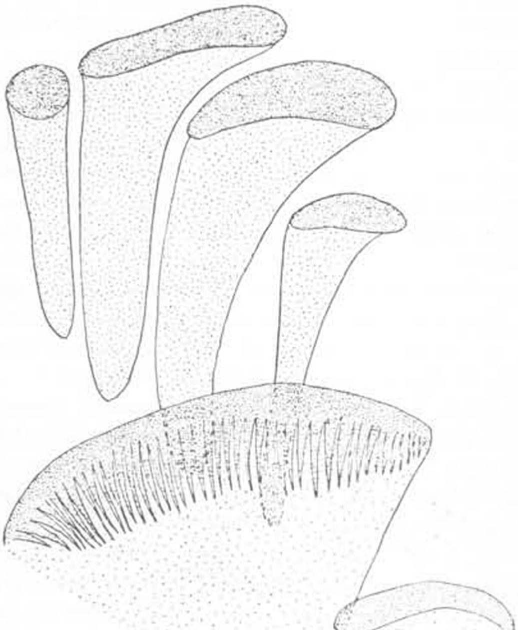

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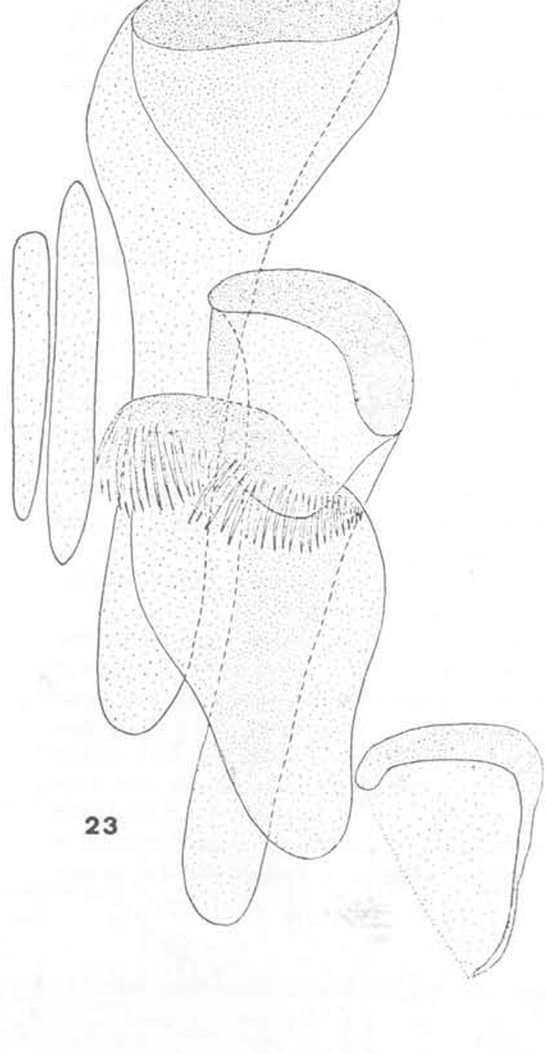

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and the teeth are most effective at the "bending plane."

Golikov and Starobogatov consider the rasp type of radula — for which a more technical term has not been proposed — as the most archaic in the Mollusca. Most other authors, such as Fretter and Graham (1962), consider the rhipidoglossate radula as the most primitive and the docoglossate radula derived from it in an as yet unexplained way. The matter remains controversial because there is no apparent affinity between these two kinds of gastropod radulae.

A comblike fringe, similar to that on the neopilinid first marginal tooth, occurs on the marginal teeth of some genera of the docoglossan limpet family Lepetidae. In the Neopilinidae the fringe is found only on the first marginal tooth, but in the Lepetidae the very similar appearing fringe is found on both pairs of marginal teeth. The origin and significance of these comblike teeth remains to be explained. Could the fringe be a clue to a more direct affinity between the Monoplacophora and the Docoglossa?

The Paleozoic monoplacophorans are found in shallow water deposits. They were probably grazing animals like modern patellacean limpets and chitons. The large and robust radular teeth in modern limpets and chitons are opaque and mineralized (Lowenstam 1967, 1971). The neopilinid radula is probably less robust than that of its fossil predecessors, but is probably similar to what was present in the extinct families of Monoplacophora. As in the chitons and docoglossan limpets, the neopilinid radula is large in proportion to body size. Its mineral content should be investigated.

The radula of the Polyplacophora, the chitons, is not especially diverse from family to family. I would expect Monoplacophora as a whole, to have had a diversity similar to that of the Polyplacophora, in which the level of organization is primitive, the family distinctions are not profound, and the species are relatively few in number.

ORIGINS

When the discovery of *Neopilina galatheae* was announced, who could have predicted that it represented but one of a small number of species of this relict group? Can it be that the *Laevipilina* branch in the Neopilinidae is represented elsewhere in the world? The possibility should be considered by those who have opportunity to dredge rocks at the edge of the continental shelf. The offshore fauna of southern California is one of the most often sampled and best known in the world. This discovery comes at a time when there are rather few new species being discovered in the area. Experienced collectors have no doubt had it on hand before, but have missed it. Many years may pass before the faunas of rocky bottoms on the outer continental shelves will be sufficiently known to answer the question.

Unfortunately, a fossil record of the abyssal fauna is not accessible. Many families of modern mollusks seem to have centers of origin in which extensive speciation has taken place. One might consider the eastern Pacific as the place of origin of the neopilinid stock, since most of the species and records are from that region. This might seem to be a foregone conclusion were it not for those species described from single records in the Indian Ocean and the mid-Pacific. The most likely explanation seems to be that accepted by most authors (e.g. Parker 1962) that the neopilinid line is a monoplacophoran offshoot that happened to invade the deep sea and has existed there in the absence of severe competition and predation since the Paleozoic. The shallow occurrence of *Vema (Laevipilina)* would thereby represent a reinvasion of the shallow water habitat from an abyssal stock.

Yet there is now an alternative theory: there is a possibility that the monoplacophorans have continued to survive at intermediate depths since the Paleozoic and that the deep-sea invasion is of relatively recent occurrence. The discovery of other monoplacophorans from intermediate depths would support this idea. However, the lack of eyes in *Vema (Laevipilina) hyalina,* a species that lives at a depth where considerable light is available, suggests that it is a derivative from forms existing in deep, lightless environments.

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Photographs are largely the work of Bertram C. Draper, Museum Associate, with several others by Armando Solis, Museum Photographer. Radular slides were prepared and photographed by Jo-Carol Ramsaran, Museum Volunteer, and drawn by Mary Butler, Museum Illustrator.

NOTES ADDED IN PROOF: 1) An account of the role of N.H. Odhner in introducing the name Monoplacophora was provided by that author (Odhner 1961). 2) In a paper just received Lowenstam (1978) has described the behavior and illustrated a living specimen of *Vema hyalina,* which he referred to as "McLean's *Vema* sp." 3) Recent efforts to find rocky bottom at the two positions mentioned for the original specimens from the Berry Collection have not been successful.

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